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High Resolution Observations of Drop Size Distribution for GPM Ground Validation

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Abstract. During the Mid-latitude Convective Cloud Experiment (MC3E), NASA's GPM GV Disdrometer and Radar Observations of Precipitation (DROP) Facility deployed an array of disdrometers and rain gauges in northern Oklahoma to sample, with high resolution, the drop size distribution (DSD) for use in development of precipitation retrieval algorithms for the GPM core satellite. The DROP Facility instruments deployed during MC3E consisted of 16 autonomous Parsivel units, 5 two-dimensional video disdrometers (2DVD), a vertical pointing K-band radar and 32 tipping bucket rain gauges. There were several rainfall events during MC3E in which rain drops exceeding 5 mm in diameter were recorded. During a convective rainfall event, one of the 2DVDs measured a large rain drop of 8 mm in diameter falling from a convective cell under which several other disdrometers revealed a broad DSD spectrum across the cell's core and median drop diameter of 3.1 mm. The NPOL radar, which was scanning over the disdrometer array in high resolution RHI mode (every 40 sec), during a stratiform rainfall event revealed a 1 km thick bright band with locally thicker segments that produced rainfall rates of 6-10 mm/hr and indications of DSD modulations as enhanced concentrations of mid-sized rain drops (1.5-3.0 mm) descended below cloud base. These observations are key in characterizing the DSD variability within the 4 km footprint of the GPM Dual-wavelength Precipitation Radar that will provide a global map of precipitation as well as DSD.

1. DROP FACILITY INSTRUMENTS


Autonomous Parsivel Unit (APU)


Two-dimensional Video Disdrometer (2DVD)


Micro-rain Radar (MRR)

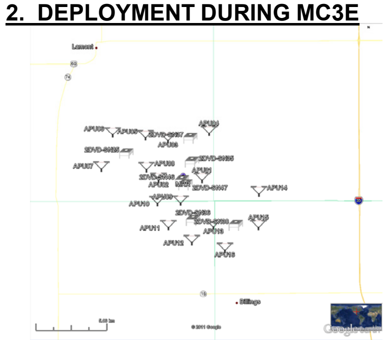

Tipping Bucket Rain Gauges


Pluvio2 Weighing Precipitation Gauge with wind fences


Hot Plate (TPS-3100)

Instrument	Description
APU	Solar-powered platform for measiring the DSD via laser-based sensor (PARSIVEL)
2DVD	Optical sensor that measures drop size AND velocity
MRR	Vertically-pointing FM-CW 24 GHz radar used to measure DSD profile
Tipping Bucket Rain Gauges	Direct measurement of rainfall amount
Pluvio2	Weighing type of precipitation gauge
Hot Plate	Measures snowfall and rainfall rate with high temporal resolution

2. DEPLOYMENT DURING MC3E



Dates: April 22, 2011 - June 6, 2011

Location: North-central Oklahoma

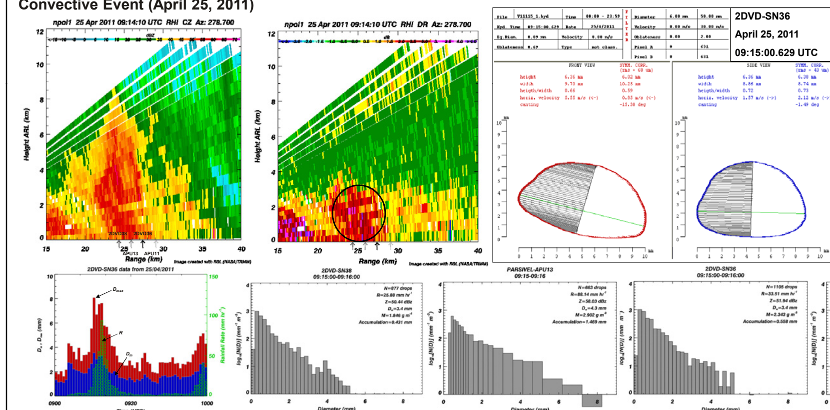
See poster 172 in this session for an overview of MC3E

Summary of instruments deployed:

- 16 APUs (PARSIVEL + 2 tipping bucket rain gauges)
- Compact two-dimensional video disdrometers (2DVD): 5 NASA + 2 DOE
- vertically pointing 24 GHz FM-CW radar (MRR)
- Joss-Waldvogel impact type disdrometer (near 2DVD-SN47)
- NASA's S-band dual-polarimetric radar (NPOL)

3. DSD VARIABILITY

Convective Event (April 25, 2011)



A very large diameter rain drop that fell from an intense deep convective rain cloud in northern Oklahoma:

D_{eq} = 8.09 mm

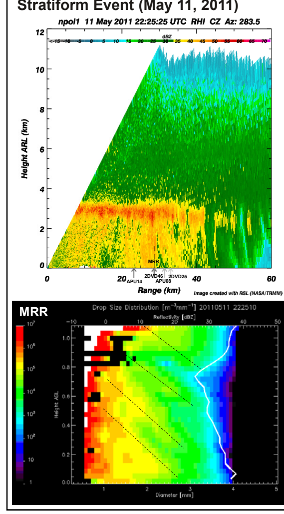
Fall velocity = 8.80 m/s

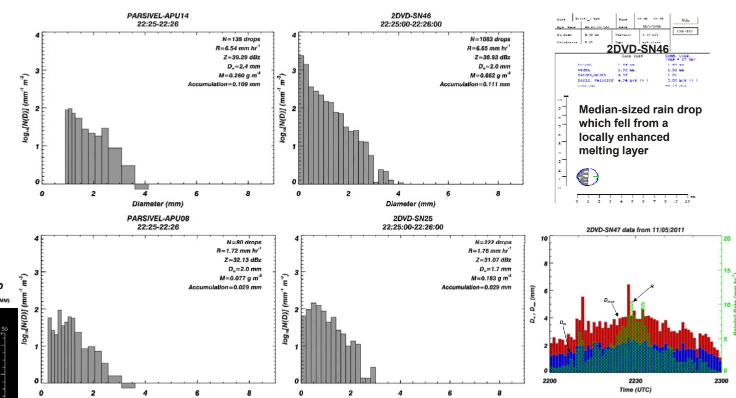
axis ratio = 0.69

Median drop diameter measured directly underneath the convective cell between 09:15-09:16 UTC was 3.1 mm

On April 25, 2011, deep, multi-cellular convection moved over the disdrometer array between 09:00-09:40 UTC and produced peak 1-min rainfall rates exceeding 70 mm/hr. A vertical cross section from NASA's S-band dual-polarimetric radar (NPOL; top left panels) shows an intense 9-10 km tall storm that occurred over two 2DVDs and two APUs, which all measured a broad DSD spectrum across the cell's core. The large values of differential reflectivity measured by NPOL (top middle) suggests large oblate drops were falling from the storm. Consequently between 09:15-09:16 UTC, the most intense rainfall and largest drops were occuring at APU13 and 2DVD-SN36, where an 8.09 mm rain drop fell to the ground, the second largest drop recorded by any of the 2dvds during MC3E (top right; the largest drop recorded was 8.59 mm from a weaker convective storm on April 26, 2011).

Stratiform Event (May 11, 2011)

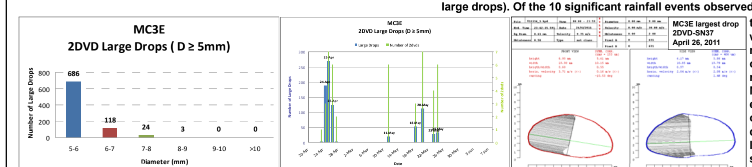




On May 11, 2011, the trailing stratiform region of a mesoscale convective system moved over the disdrometer array between 18:30-23:00 UTC. The NPOL radar was operating in RHI mode over several of the disdrometers, above which a bright band signature was centered at 2.8 km ARL. The bright band in this region varied between 1-1.5 km thick, and disdrometers below the thickest parts of the bright band layer (APU14, 2DVD-SN46, 2DVD-SN47) measured stratiform rainfall rates exceeding 6 mm/hr and rain drops larger than 3-4 mm in diameter. Also, the MRR was collecting 10-sec vertical profiles below this locally thick bright band, and several clusters of enhanced drop concentration, N(D), with size sorting was evident between 22:25-22:26 UTC as the drops descended below the locally thick bright band. The occurrence of these enhanced clusters of N(D) at the ground correlates with the modulation of DSD broadening measured by 2DVD-SN46.

4. FREQUENCY OF LARGE DROPS

The large drops are important since they greatly influence the radar reflectivity, which is a key measurement used in DSD retrievals from weather radar. During MC3E, the seven 2DVDs measured over 4.7 million rain drops, and 831 of those had equivalent spherical drop diameters exceeding 5 mm (i.e., large drops). Of the 10 significant rainfall events observed by the disdrometer array during MC3E, six of them produced mainly convective rainfall and were responsible for 83% of the large drops measured by the 2DVDs. The convective event on April 24, 2011 produced 32% of the large rain drops measured by the 2DVDs during MC3E. The four mostly stratiform rainfall events produced a significantly fewer number of large drops as well as a smaller median drop diameter compared to the convective events, likely due to the melting of hail / graupel as suggested by the NPOL images of the April 25th case shown above.



5. FUTURE WORK

The large drops observed with the 2DVDs will be used to validate the large drops identified by CSU's hydrometeor identification algorithm that is being applied to the NPOL dataset collected during MC3E. Furthermore, to improve the DSD retrievals with dual-polarimetric radars participating in MC3E, scattering simulations will be conducted with the 2DVD observations. In order to increase the sampling of large drops during a rainfall event, several 2DVDs will be deployed closely together at NASA's Wallops Flight Facility beginning this spring and summer.

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